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METHOD AND SYSTEM FOR OPTIMAL ROUTING  
OF CALLS IN A BASE STATION SYSTEM

CROSS-REFERENCES TO RELATED APPLICATIONS

This Application for Patent claims the benefit of priority from, and hereby incorporates by reference the entire disclosure of, co-pending U.S. Provisional Application for Patent Serial  
5 No. 60/177,819, filed January 25, 2000.

This Application for Patent also incorporates by reference the entire disclosure of commonly-assigned, co-pending U.S. Application for Patent Serial No. 09/494,606, filed January 31, 2000.

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Each BSC in a GSM network can control a plurality (typically hundreds) of radio cells. In other words, each BSC (e.g., 16) interworks with a plurality (hundreds) of BTSs via respective Abis interfaces. Each BTS (e.g., 14) is responsible for the transmission and reception of radio signals over an air interface, Um, in one cell. Consequently, the number of cells in a GSM BSS is equal to the number of BTSs in that BSS. As such, the BTSs are geographically distributed to provide adequate radio coverage of a BSC area, which forms part of a GSM Public Land Mobile Network (PLMN).

Additionally, the BTSs provide the capacity to carry a plurality of connections (calls) between Mobile Stations (MSs) (e.g., 22) and respective BSCs. In the GSM, each BTS is equipped with one or more Transceivers (TRXs). Each such TRX (not shown) is capable of handling eight timeslots of a Time Division Multiple Access (TDMA) frame. Furthermore, each such timeslot can be assigned different combinations of logical channels, such as, for example, Broadcast Control Channels

(BCCHs) and Common Control Channels (CCCHs), Stand-alone Dedicated Control Channels (SDCCHs), and Traffic Channels (TCHs).

FIGURE 2 is a block diagram of an Internet Protocol (IP)-based BSS 100, which has been developed by Ericsson. A more

datagrams to one or more Transmitter/Receivers (TRXs) and also for connecting a plurality of RBSs in various topologies.

A second node connected to the IP network 108 is a GateWay (GW) 104. The GW 104 can be used to terminate the A-interface.

5 Also, the GW 104 can perform a conversion from one protocol (e.g., SS7 protocol) to another protocol (e.g., Transmission Control Protocol (TCP)/IP). The GW 104 can also include a Media GW (MGW) which functions similarly to existing Transcoder Controllers in an Ericsson implementation of the GSM model. The  
10 MGW (not shown) includes a pool of Transcoder/Rate Adaptor (TRA) devices (not shown), which, when allocated, are connected to the A-interface. However, the IP network (e.g., GSM) side of the TRAs in the MGW are connected to respective UDP ports. Preferably, the GW 104 is connected to the IP network 108 via a  
15 separate router (not shown).

A third node connected to the IP network 108 is a Radio Network Server (RNS) 106. The RNS 106 functions similarly to a BSC used for implementing a GSM model. A primary difference

between the RNS 106 and a BSC is that the RNS does not switch  
payloads and does not include a Group Switch (GS). As such, the  
RNS 106 preferably carries signalling only, and includes a pool  
of processors (e.g., the number of processors determined by  
5 capacity requirements). The RNS 106 provides a robust, general  
purpose distributed processing environment, which can be based  
on a standard operating system such as, for example,  
SUN/Solaris™. The RNS 106 can serve one or more logical BSCs  
and is preferably connected to the IP network 108 via a separate  
10 router. As such, the payload can be routed directly between the  
GW 104 and RBS 102, without passing through the RNS' 106  
processors. The A-interface signalling is routed between the  
RNS 106 and GW 104.

FIGURE 3 is a block diagram of an implementation of a BSS,  
15 which can be used to illustrate the significant technical  
problems that need to be resolved. Referring to FIGURE 3, in  
accordance with GSM Technical Specification (TS) 08.08, in a BSS  
(e.g., 200), all connections for the circuit-switched services

are conveyed via the A-interface. As such, for example, if a speech call is being conducted between two parties in neighboring cells, the call is routed via the MSC 212. This routing occurs because the BSS 200 does not know that the two

5 "half calls" (e.g., Signalling Connection-a 214 and Signalling Connection-b 216) belong to the same "full call" or conversation. This approach results in a so-called tromboning effect, which has significant disadvantages such as relatively high transmission costs, degraded speech quality, and longer

10 delay. Consequently, with the increasing success and market penetration of mobile telephony, the number of mobile-to-mobile calls is expected to increase dramatically, and based on past experience, most of these calls will be local (i.e., within one BSS).

15 As illustrated by the BSS 200 shown in FIGURE 3, in existing BSS implementations, semi-permanent circuit-switched connections are used between the BTSs 206, 208 and the BSC 210. The MSC 212 sends an Assignment Request Message to the BSS 200,

which informs the BSS what circuit is conveying the "half call".  
The Circuit Identity Code (CIC) Information Element (IE) in the  
Assignment Request Message provides the actual reference point  
information for the call. For example, the "half call" for  
5 Mobile Station-a (MS-a) 202 is associated with CIC-a 218, and  
the "half call" for MS-b 204 is associated with CIC-b 220. A  
signalling connection (e.g., Signalling Connection-a and -b 214,  
216) is provided between MSC 212 and BSC 210 and MS-a 202 or MS-  
b 204 for each "half call". In any event, MSC 212 is required  
10 to have complete control of the "full call" for a number of  
reasons, such as, for example, the MSC maintains the charging  
accounts, provides the dialling tone, and handles subscriber  
services (e.g., call transfer). In any event, as described in  
detail below, the present invention successfully resolves the  
15 above-described problems, and also resolves other related  
problems.

SUMMARY OF THE INVENTION

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In accordance with a preferred embodiment of the present invention, a method and system are provided for optimal routing of calls in an IP-based BSS, whereby a plurality of new messages  
5 are introduced on the A-interface. One such message informs the BSS that the CICs included in the message can be connected to the BSS to provide optimal routing of one or more calls. Another such message informs the BSS that the CICs included in the message are to be restored as separate CICs on the A-  
10 interface. The provision of such messages overcomes the above-described and other related disadvantages of the existing and developing BSS implementations.

An important technical advantage of the present invention is that the tromboning problems associated with existing BSS  
15 implementations are resolved.

Another important technical advantage of the present invention is that no circuit-switching procedures are involved,





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FIGURE 5 is a block diagram of an IP-based BSS, which illustrates the execution of a "Join CIC" procedure, in accordance with the preferred embodiment of the present invention;

FIGUREs 6A and 6B are related block diagrams of an IP-based BSS, which can be used to implement a handover procedure in accordance with the preferred embodiment of the present invention; and

- 5       FIGUREs 7A and 7B are related block diagrams of an IP-based BSS, which can be used to implement simultaneous handovers at two ends of a connection, in accordance with the preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

The preferred embodiment of the present invention and its advantages are best understood by referring to FIGURES 1-7B of the drawings, like numerals being used for like and  
5 corresponding parts of the various drawings.

Essentially, in accordance with a preferred embodiment of the present invention, a method and system are provided for optimal routing of calls in an IP-based BSS, whereby a plurality of new messages are introduced on the A-interface. One such  
10 message informs the BSS that the CICs included in the message can be connected to the BSS to provide optimal routing of one or more calls. Another such message informs the BSS that the CICs included in the message are to be restored as separate CICs on the A-interface. The provision of such messages overcomes the  
15 above-described and other related disadvantages of the existing and developing BSS implementations.

Specifically, in accordance with the preferred embodiment of the present invention, two new messages can be introduced for

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use in a BSS on an A-interface. One such message, hereinafter referred to as a "Join CIC" message, for example, includes IEs with information about which CICs and Signalling Connections belong to a single conversation, and thus the associated call  
5 can be routed in an optimal fashion. A second such message, hereinafter referred to as a "Restore CIC" message, for example, includes IEs with information about which CICs are to be restored separately on the A-interface. For this exemplary embodiment, the MSC sends a "Join CIC" message to the BSS, in  
10 order to inform the BSS that the CICs included in the message can be connected in the BSS in a manner that will provide optimal routing. However, the signalling connections towards the MSC should be maintained, so that any of the MS' parties can be capable of invoking subscriber services, for example, if  
15 required.

FIGURE 4 is a block diagram of an IP-based BSS 300, which can be used to implement a preferred embodiment of the present invention. As illustrated by the IP-based BSS 300 shown in

FIGURE 4, the RNS 307 keeps track of all the connections in the BSS. The connection point at a BTS (306 or 308) or the GW 311 is associated with an IP address and port number. A BSC is divided into a server part, RNS 307, and GW 311 (payload  
5 handling part).

Referring to FIGURE 4, the exemplary embodiment is shown with connections already setup. As shown, if the MSC 312 sends a "Join CIC" message to the BSS 300, and thereby executes the Join CIC procedure on either of the two Signalling Connections  
10 (a or b) 314 or 316, the RNS 307 can respond by connecting BTS<sub>a</sub> 306 to BTS<sub>b</sub> 308. This function can be accomplished by the RNS 307 ordering BTS<sub>a</sub> 306 to start sending speech packets to BTS<sub>b</sub> 308. Consequently, instead of sending speech packets to IP/port-a<sub>2</sub> 303b, BTS<sub>a</sub> 306 sends speech packets to IP/port-b<sub>1</sub>  
15 305a. The RNS 307 also orders BTS<sub>b</sub> 308 to start sending speech packets to BTS<sub>a</sub> 306. Consequently, instead of sending speech packets to IP/port-b<sub>2</sub> 305b, BTS<sub>b</sub> 308 sends speech packets to IP/port-a<sub>1</sub> 303a. The RNS 307 also instructs the GW 311 to

suspend the sending of packets to BTS<sub>a</sub> 306 and BTS<sub>b</sub> 308 (via IP/port-a<sub>1</sub> 303a and IP/port-b<sub>1</sub> 305a).

A result of executing the "Join CIC" procedure in the above-described fashion is shown in FIGURE 5. As illustrated in  
5 FIGURE 5, by the MSC 312 sending a "Join CIC" message to the BSS 300 in accordance with the preferred embodiment, a more direct connection 322 for speech packets can be made between BTS<sub>a</sub> 306 and BTS<sub>b</sub> 308 via IP/port-a<sub>1</sub> 303a and IP/port-b<sub>1</sub> 305a in IP network 309.

10 If the MSC 312 desires to restore the original setup (e.g., as shown in FIGURE 4), the MSC can send a "Restore CIC" message to the BSS 300. In this case, the RNS 307 instructs BTS<sub>a</sub> 306 to start sending the speech packets to IP/port-a<sub>2</sub> 303b, and also instructs BTS<sub>b</sub> 308 to start sending the speech packets to  
15 IP/port-b<sub>2</sub> 305b. The RNS 307 instructs the GW 311 to resume sending speech packets for the two connections IP/port-a<sub>2</sub> 303b and IP/port-b<sub>2</sub> 305b.

Typically, in most cases, the above-described restoration procedure (instigated by the "Restore CIC" message for the preferred embodiment) should not be needed. Therefore, in most cases, the optimal routing procedure (instigated by the "Join  
5 CIC" message, for the preferred embodiment) can be maintained until the ongoing call is cleared from the MSC 312. Nevertheless, an issue that arises in this regard is that when speech information is conveyed directly between BTSS (and the MSs), the same speech coding should be employed in both  
10 directions. As such, in order to reach agreement about common speech coding in this regard, negotiations between the two MSs and the BSS have to be conducted. Notably, however, the European Telecommunications Standards Institute (ETSI) has set forth rules for conducting such negotiations.

15 For this exemplary embodiment, the connection path in the IP network 309 between the transcoders in the GW 311 and the BTSS 306 and 308, the transcoders themselves, and appropriate communication resources in the MSC 312 are maintained during a

call during execution of a "Join CIC" procedure for optimal routing. The purpose for this practice is to make sure that these resources remain available in the event that the original connection path has to be re-established. (Note that a  
5 connection path in an IP network is actually reserved bandwidth and not a physical path, as in a circuit-switched network.) If the MSC 312 desires to intervene in a call (e.g., a third party is to be connected to the call), the MSC again informs the RNS 307 by sending a "Restore CIC" message to the RNS so that the  
10 RNS can reconnect the MSC into the call. The re-connection can be made by replacing existing IP addresses with appropriate new IP addresses in the BTSs 306 and 308.

Essentially, for this embodiment, a handover procedure for directly connected BTSs (e.g., during execution of a "Join CIC"  
15 procedure) can also be accomplished by replacing existing IP addresses with appropriate new IP addresses. For a relatively short duration during the handover procedure, a BTS sends speech packets to both an "old" and "new" BTS. When the handover



procedure is completed, the "old" BTS can be removed from the call. As such, once a mutual connection is established between the two BTSs upon completion of the handover procedure, the "old" BTS can be completely disconnected from the call.

5 However, if the handover procedure is unsuccessful, the "new" BTS can be removed from the call and the original connection can continue to proceed. If a subscriber leaves the RNS's area, the remaining connection is disconnected from the transcoder in the GW involved.

10 Specifically, FIGURES 6A and 6B are related block diagrams of an IP-based BSS 400, which can be used to implement the preferred embodiment of the present invention. In particular, the block diagrams shown in FIGURES 6A and 6B are useful to illustrate an example of a handover procedure that can be  
15 performed for one MS at a time. Referring to FIGURE 6A, for this example, it can be assumed that RNS 407 has decided to perform a handover procedure for MS-b 404, and has identified BTS<sub>c</sub> 426 as a candidate recipient BTS. Also assume that an

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optimal routing connection 422 has already been established  
(e.g., using a "Join CIC" procedure) between BTS<sub>a</sub> 406 and BTS<sub>b</sub>  
408. RNS 407 activates a radio channel in BTS<sub>c</sub> 426 and orders  
BTS<sub>c</sub> 426 to send and receive packets (speech frames) to and from  
5 IP/port-a<sub>1</sub> 403a. RNS 407 also orders BTS<sub>a</sub> 406 to start sending  
and receiving packets to and from IP/port-b<sub>1</sub> 405a and IP/port-c<sub>1</sub>  
405c. Next, RNS 407 orders MS-b 404 to perform the handover  
procedure. Once MS-b 404 has established a connection with BTS<sub>c</sub>  
426 (via a radio air interface), the BSS 400 moves the  
10 Signalling Connection-b 416 to BTS<sub>c</sub> 426. Next, RNS 407 orders  
BTS<sub>a</sub> 406 to stop sending packets to BTS<sub>b</sub> 408. RNS 407 then  
releases BTS<sub>b</sub> 408 from the connection (and the call). As such,  
the RNS 407 controls both ends of the call and also controls the  
entire handover sequence. FIGURE 6B shows the resulting  
15 connection 424 after the handover procedure has been completed.  
Notably, the resulting connection 424 is also configured for  
optimal routing (e.g., instigated by a "Join CIC" procedure)

through the IP network 409, in accordance with the preferred embodiment of the present invention.

FIGURES 7A and 7B are related block diagrams of an IP-based BSS 500, which also can be used to implement the preferred  
5 embodiment of the present invention. In particular, the block diagrams shown in FIGURES 7A and 7B are useful to illustrate an example of a handover procedure that can be performed simultaneously for MSs at the ends of a connection. Referring to FIGURE 7A, for this example, it can be assumed that RNS 507  
10 is required to perform simultaneous handovers at both ends of a connection (e.g., for MS-a 502 and MS-b 504). It can also be assumed, for this example, that a connection exists between IP/port-a<sub>1</sub> 503a and IP/port-b<sub>1</sub> 505a prior to a handover procedure. In order to prepare for the two handovers, for this  
15 example, RNS 507 sets up (at handover) the following connective relationships via the IP network 509 (while also activating a radio channel in BTS<sub>c</sub> 526 and BTS<sub>d</sub> 528): IP/port-a<sub>1</sub> 503a to IP/port-b<sub>1</sub> 505a; IP/port-a<sub>1</sub> 503a to IP/port-c<sub>1</sub> 505c; IP/port-b<sub>1</sub>

505a to IP/port-d<sub>1</sub> 503c; and IP/port-c<sub>1</sub> 505c to IP/port-d<sub>1</sub> 503c.  
Once these preparations are completed, RNS 507 orders both MSs  
502 and 504 to perform their respective handover procedures. In  
response, the MSs 502 and 504 establish their new connections  
5 via radio air interfaces to BTS<sub>d</sub> 528 and BTS<sub>c</sub> 526, respectively.  
The BSS 500 then moves Signalling Connections-a 514 and  
Signalling Connection-b 516 from BTS<sub>a</sub> 506 and BTS<sub>b</sub> 508 to BTS<sub>c</sub>  
526 and BTS<sub>d</sub> 528. Next, RNS 507 releases BTS<sub>a</sub> 506 and BTS<sub>b</sub> 508  
from the connection. In accordance with the preferred  
10 embodiment, the "old" optimally routed connection 522 is  
replaced by the "new" optimally routed connection 523 via the IP  
network 509 once the "simultaneous" handover procedures are  
completed. The "new" optimally routed connection 523 is shown  
for illustrative purposes in the block diagram of FIGURE 7B.

15 In summary, in accordance with the preferred embodiment of  
the present invention, calls can be optimally routed via an IP  
network. As such, the existing problems related to tromboning  
can be successfully resolved. This solution is amplified in an

IP-based BSS, because no switching of circuits is needed. Instead of setting up switches to re-direct a call, the BTSs can be informed about the new destination addresses. The IP network then routes the packets via the new destination addresses. In  
5 a circuit-switched environment, a BSC would need to know exactly which switches to operate in the network involved (i.e., the network topology has to be known). An RNS does not need to know the topology of an IP network.

Although a preferred embodiment of the method and apparatus  
10 of the present invention has been illustrated in the accompanying Drawings and described in the foregoing Detailed Description, it will be understood that the invention is not limited to the embodiment disclosed, but is capable of numerous rearrangements, modifications and substitutions without  
15 departing from the spirit of the invention as set forth and defined by the following claims.